Geospace Imaging Exploration Science Matrix – Three top priorities are shaded.

Imaging Exploration Theme	RFA 2002	Objectives / Investigations	Types of Imaging	Phenomena Observed	Measurement Requirements	Technology Development
1	1f	Coupling of Ring Current, inner and outer plasmasphere, ionosphere	ENA, EUV, FUV	O.N2 ratio, ionospheric conductivity, TEC on nightside, 3-D perspective of plasmasphere and ring current; conjugate FUV observations, multiple perspective EUV and ENA observations	Stabilized platform continuous viewing (2 s/c in circular orbit)- ENA: FOV to L=8, 10-20 improvement in sensitivity, FUV: 10s and 5km resolution, 10 counts/kR/s at 135.6nm, 135.6nm, LBHS, LBHL, EUV: improvement of 10 in sensitivity, larger FOV	ENA: UV noise suppression, Foil/grating technology, EUV: improved mirror performance and out-of-band rejection, ability to isolate 91.1nm, FUV hyperspectral imaging, large telemetry and image compression
1	3d	Mars atmospheric coupling, where did the water go?	ENA, IR, FUV	atmospheric escape/ion outflows, aerosols, CO2 atmospheric glow, O+	IR: global scale diurnal resolution, FUV: Doppler shifted O+, ENA: 10eV-10keV, H & O separation, 10 min resolution,	Imaging ion outflows could be done via ENA imaging or, in principle, using optical imaging. In the ENA imaging regime, a low energy ENA imager such as LENA on IMAGE is required. However, this has not been fully successful for reasons that are not fully understood, but which are through to involve multi-collision scattering processes. Hyper-spectral images would provide an attractive method of observation due to the need for spectral information in each pixel. Other emitting ionic species that may participate in the outflows at Earth or elsewhere could provide similar avenues of observation.

Geospace Imaging Exploration Science Matrix (continued) – Three top priorities are shaded.

Imaging Exploration Theme	RFA 2002	Objectives / Investigations	Types of Imaging	Phenomena Observed	Measurement Requirements	Technology Development
1	1e	How does solar forcing affect Dayside conductivity	ENA, EUV, FUV	O.N2 ratio, ionospheric conductivity, TEC on nightside, 3-D perspective of plasmasphere and ring current	**Stabilized platform – ENA:** FOV to L=8, 10-20 improvement in sensitivity, **FUV:** 10s and 5km resolution, 10 counts/kR/s at 135.6nm, 135.6nm, LBHS, LBHL, **EUV:** improvement of 10 in sensitivity, larger FOV	**ENA:** UV noise suppression, Foil/grating technology, **EUV:** improved mirror performance and out-of-band rejection, ability to isolate 91.1nm, **FUV** hyperspectral imaging, large telemetry and image compression
1	1e	Mass and energy transfer across the Magnetopause	Radio tomography	Plasma density maps and in situ measurements	Multiple satellites	No new technology is needed, only the trust that multiple satellites can be built and launched
1	1f	Does solar / magnetospheric / ionospheric forcing have any affect on troposheric lightning?	VIS and X-Ray imagers	lightning strike location and x-ray emission, precipitating particles	Continuous lightning imaging – location, time, characteristic (total lightning) – 2 millisecond Sprite imaging Spherics activity Trapped particle populations including pitch angles Precipitating particles – particle spectrum in a second Hiss spectrum – in 0.25 sec. X-ray imager – soft and hard	Sprite / lightning discrimination
1	1f	global response of the neutral atmosphere to storm inputs and normal solar forcing	EUV, FUV	ion outflows, full disk images of 135.6 nm O, N2+ 1st negative system, NO, 5Re FOV for EUV/HeII, TEC	Stabilized platform at L1 or geosynchronous, earth pointing, 25 km resolution, 1KR sensitivity, 30 sec resolution.	Compact hyperspectral camera

Geospace Imaging Exploration Science Matrix (continued) – Three top priorities are shaded.

Imaging Exploration Theme	RFA 2002	Objectives / Investigations	Types of Imaging	Phenomena Observed	Measurement Requirements	Technology Development
1	1f	Long term affects of ion outflow at Mars – image ion outflow	ENA, FUV	H, O, Neutral and ion atmospheric escape	**ENA:** H, O, 10eV-1keV, 4 pi sr imaging, 60 sec; **FUV:** Doppler shifted O+ emission	**ENA:** suppression, surface conversion
1	3b	understanding how pressure pulses affect magnetosphere	FUV	dayside auroral emissions, solar wind plasma and magnetic field	full auroral oval on times scale < 60 sec, 50 km resolution,	
1	3d	exploring the mid-latitude nightglow	FUV imagers	electron density	large scale images with 60 sec cadence, for > 6 hours, 10 km resolution, 135.6 nm,	compact imagers
1	3d	exploring the dayside airglow	FUV imagers	electron density, O/N2 ratio	large scale images with 60 sec cadence, for > 6 hours, 25 km resolution, 135.6nm LBHS, LBHL	compact hyperspectral imaging
1		investigate the atmospheric-ionospheric dynamic coupling	Visible and IR	atmospheric waves, winds, temperatures, temperature, cloud properties	10 km spatial resolution, high vertical resolution	
1	1e	What is the driver for variability – internal or external driver? Imaging plasmasheet	radio tomography of the plasmasheet, ENA, FUV	plasma density maps and in situ measurements, auroral emissions	plasma density maps on minute time scale (BBF time scale), multiple satellites, stabilized platform for auroral measurements LBHL, LBHS, Proton auroral emissions, global FOV	

Geospace Imaging Exploration Science Matrix (continued) — Three top priorities are shaded.

Imaging Exploration Theme	RFA 2002	Objectives / Investigations	Types of Imaging	Phenomena Observed	Measurement Requirements	Technology Development
2	1f	Understanding the dynamic aurora	UV and Visible imagers	small and large scale structures, in situ particles and fields, currents and average precipitating energy, conjugate observations	Small scale imaging at 30Hz, LBHS and LBHL large scale imaging, simultaneous in-situ plasma and field measurements on same time scale. Continuous observation of footprint of spacecraft field line for >15 s	Improved data compression techniques, larger apertures, increased sensitivity, hyperspectral detectors, increased telemetry bandwidth; 'smart' high resolution detector that can digitally zoom
2	1f	Exploring the plasma processes of the Io and Europa Torus in the Jovian magnetosphere	EUV, FUV, Radio Sounding	emission of S++, aurora, density structures	**EUV:** 68.5 nm, hyperspectral from 50-100 nm **FUV:** hyperspectral auroral imaging from 100-180 nm Radio: 3kHz-1MHz	hyperspectral imaging, out-of-band rejection, EUV mirror performance
2	1f	Imaging Mercury's magnetosphere	ENA	magnetospheric ions interacting with low-altitude exosphere and surface	**ENA:** high mass resolution of ENA's, 10eV-1keV, time resolution 30 sec	**ENA:** UV suppression , large G-factor, mass resolution, surface conversion
2	2c	Large vs. small scale structures - Filamentation	UV and VIS imagers	aurora emission combined with in situ measurements, camera with high resolution and multiple wave lengths	Cameras with high resolution needs ~<1 km optical resolution at 100 km and a cadence of <1 image per second, cameras with multiple wavelength needs to operate in wave lengths so the spectra shape of the precipitating electrons can be determined	Create satellite imager that can observe the magnetic footprint of the satellite for continuous time periods with the right resolutions and cadence with to high signal to noise ratio

Geospace Imaging Exploration Science Matrix (continued) — Three top priorities are shaded.

Imaging Exploration Theme	RFA 2002	Objectives / Investigations	Types of Imaging	Phenomena Observed	Measurement Requirements	Technology Development
2	1f	Hot plasma dynamics	ENA, EUV, FUV	magnetospheric global ion dynamics, cold gas distribution, auroral dynamics	**ENA**: 2 degree resolution, energies from 5 keV to 200 keV, separate H from O, S **EUV**: High Sensitivity, high spectral resolution, wavelength coverage for H, O, S, OH gasses **FUV**: Sensitivity to see diffuse aurora, wavelength coverage to get ionospheric conductances from energy deposition	For all, capability to operate in high radiation and energetic particle flux environment; rad-hard parts

Exploration Themes:

1. **Coupling between diverse plasma regimes from the solar wind to the atmosphere**

2. **Acceleration of particles and the associated energy transfer**

Science Objectives	Research Focus Areas	Investigations
Understand the Changing Flow of Energy and Matter throughout the Sun, heliosphere and planetary environments	Understand the structure and dynamics of the Sun and solar wind and the origins of the magnetic variability.	(1a) Understand the transport of mass, energy and momentum within the sun and into the solar atmosphere.
		(1b) Determine through direct and indirect measurements of the origins of the solar wind, its magnetic field, and energetic particles.
	Determine the evolution of the heliosphere and interaction with the galaxy.	(1c) Determine the evolution of the heliosphere on its largest scales.
		(1d) Determine the interaction between the Sun and the galaxy
	Understand the response of magnetospheres and atmospheres to external and internal drivers.	(1e) Differentiate among the dynamic magnetospheric responses to the steady and non-steady drivers/
		(1f) Explore the chain of action/reaction processes that regulate solar energy transfer into and through the coupled magnetosphere-ionosphere-atmosphere system.

Science Objectives	Research Focus Areas	Investigations
Explore the fundamental physical processes of space plasma systems	Discover how magnetic fields are created and evolve and how charged particles are accelerated.	(2a) Discover the mechanisms for creation, annihilation and reconnection of magnetic fields.
		(2b) Determine how charged particles are accelerated to enormous energies.
	Understand coupling across multiple scale lengths its generality in plasma systems.	(2c) Understand how small scale processes couple to large scale dynamics.
		(2d) Test the generality of processes in diverse plasma environments.
Define the origins and societal impacts of variability in the Sun-Earth connection.	Develop the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect the Earth.	(3a) Develop the capability to predict solar activity and its consequences in space.
		(3b) Develop an understanding of the evolution of solar disturbances.
	Specify and enable prediction of changes to the Earth's radiation environment, ionosphere, and upper atmosphere.	(3c) Develop the capability to specify and predict changes to the radiation environment.
		(3d) Develop an understanding of the upper atmosphere response to solar forcing and coupling from the lower atmosphere.